Claims

What Is Claimed Is:

1. A method for separating isotopes of an element comprising:

a) directing a first laser pulse onto a surface of a target at a first energy fluence sufficient to generate a plasma comprising ionized isotopic species and to cause spatial separation of said ionized isotopic species;

b) after step a), allowing said plasma to expand to a density approximately equal to a critical density of said plasma; and

c) after step b), directing a second laser pulse onto said plasma at a second energy fluence to further spatially separate said ionized isotopic species.

2. The method of Claim 1 wherein said critical density further comprises a density of said plasma when a frequency of said plasma approximately equals a frequency of said second laser pulse.

3. The method of Claim 1 further comprising:

d) depositing said spatially separated ionized isotopic species on a substrate.

4. The method of Claim 1 further comprising:

d) extracting said spatially separated ionized isotopic species using a carrier gas.

5. The method of Claim 1 wherein said second energy fluence is approximately equal to said first energy fluence.

6. The method of Claim 5 wherein said first and second energy fluences are approximately equal to 1.1 kJ/cm^2.

7. The method of Claim 1 wherein said second energy fluence is not equal to said first energy fluence.

8. The method of Claim 1 wherein said step b) progresses from about 1 to about 40 picoseconds.

9. The method of Claim 1 wherein said step b) progresses from about 3.5 to about 11.5 picoseconds.

10. The method of Claim 1 wherein said step b) progresses for about 5 picoseconds.

11. The method of Claim 1 wherein said step b) progresses for about 10 picoseconds.

12. A method for separating isotopes of an element comprising:

a) directing a first laser pulse onto a surface of a target having a first isotopic distribution, at an energy fluence sufficient to generate a plasma comprising ionized isotopic species and to cause spatial separation of said ionized isotopic species; and

b) after step a), directing a plurality of sequentially time delayed pumping laser pulses onto said plasma to further spatially separate said ionized isotopic species;

wherein the time delay between consecutive pumping laser pulses is sufficient to allow said plasma to expand to a density approximately equal to a critical density of said plasma.

13. The method of Claim 12 wherein said critical density further comprises a density of said plasma when a frequency of said plasma approximately equals a frequency of said second laser pulse.

14. The method of Claim 12 further comprising:

c) depositing said spatially separated ionized isotopic species on a substrate whereby a deposit is formed having a region with a second isotopic distribution different from said first isotopic distribution.

15. The method of Claim 12 further comprising:

c) extracting said spatially separated ionized isotopic species using a carrier gas.

16. The method of Claim 12 wherein an energy fluence of each of said plurality of pumping laser pulses is approximately equal to said energy fluence of said first laser pulse.

17. The method of Claim 16 wherein said energy fluence is approximately equal to 1.1 kJ/cm^2.

18. The method of Claim 12 wherein an energy fluence of each of said plurality of pumping laser pulses is different from said energy fluence of said first laser pulse.

19. The method of Claim 12 wherein said time delay between consecutive pumping laser pulses is in a range from about 1 to about 40 picoseconds.

20. The method of Claim 12 wherein said time delay between consecutive pumping laser pulses is in a range from about 3.5 to about 11.5 picoseconds.

21. The method of Claim 12 wherein said time delay between consecutive pumping laser pulses is approximately equal to 5 picoseconds.

22. The method of Claim 12 wherein said time delay between consecutive pumping laser pulses is approximately equal to 10 picoseconds.

23. A method for separating isotopes of an element comprising:

a) directing a laser beam onto a surface of a target having a first isotopic distribution at an energy fluence sufficient to cause spatial separation of said ionized isotopic species;

b) after step a), allowing said plasma to expand to a density approximately equal to a critical density of said plasma; and

c) after step b), directing one or more time delayed second laser pulses onto said plasma at a second energy fluence to further spatially separate said ionized isotopic species, the time delay between consecutive second laser pulses being sufficient to allow said plasma to expand to a density approximately equal to said critical density of said plasma.

24. The method of Claim 23 further comprising:

d) depositing said spatially separated ionized isotopic species on a substrate whereby a deposit is formed having a region with a second isotopic distribution different from said first isotopic distribution.

25. The method of Claim 23 further comprising:

d) extracting said spatially separated ionized isotopic species using a carrier gas.

26. The method of Claim 23 wherein said second energy fluence is approximately equal to said first energy fluence.

27. The method of Claim 23 wherein said second energy fluence is not equal to said first energy fluence.

28. The method of Claim 23 wherein said time delay between consecutive second laser pulses is in a range from about 3.5 to about 11.5 picoseconds.

29. A method for separating chemical species comprising:

a) directing a laser beam onto a surface of a target at an intensity and wavelength sufficient to generate a plasma comprising chemical species and to cause spatial separation of said chemical species.

30. The method of Claim 29 further comprising:

b) depositing said spatially separated chemical species on a substrate, whereby a deposit is formed having a first region which is relatively rich in a selected chemical species and a second region which is relatively lean in said selected chemical species.

31. The method of Claim 29 further comprising:

b) extracting said spatially separated chemical species using a carrier gas.

32. The method of Claim 29 wherein said intensity is in a range of about 10^9 watts/cm^2 to 10^{18} watts/cm^2.

33. The method of Claim 29 wherein said wavelength is in a range of about 200 nanometers to about 1 micrometer.

34. The method of Claim 29 wherein said laser beam comprises one or more pulses each having a duration in a range of nanoseconds to femtoseconds.

35. The method of Claim 30 further comprising:

c) directing an additional laser beam onto a selected one of said first and second regions at an intensity and wavelength sufficient to generate a second plasma comprising chemical species and to cause spatial separation of said chemical species of said selected region.

36. The method of Claim 35 further comprising:

d) depositing said spatially separated chemical species of step (c) on a substrate, whereby a second deposit is formed having a third region with a chemical distribution different from said selected region.

37. The method of Claim 35 further comprising:

d) extracting said spatially separated chemical species of step (c) using a carrier gas.

38. The method of Claim 29 further comprising:

b) after step a), allowing said plasma to expand to a density approximately equal to a critical density of said plasma; and

c) after step b), directing a second laser pulse onto said plasma at a second energy fluence to further spatially separate said chemical species.

39. The method of Claim 38 wherein said critical density further comprises a density of said plasma when a frequency of said plasma approximately equals a frequency of said second laser pulse.

40. A method of modifying the ionic characteristics of a plasma comprising:

a) directing a first laser pulse onto a surface of a target at a first energy fluence sufficient to generate said plasma having a first ionic characteristic;

b) after step a), allowing said plasma to expand to a density approximately equal to a critical density of said plasma; and

c) after step b), directing a second laser pulse onto said plasma at a second energy fluence to modify said first ionic characteristic to a second ionic characteristic.

41. The method of Claim 40 wherein said density further comprises a density between about 65% critical density and critical density.

42. The method of Claim 40 wherein said step b) further comprises about 5 picoseconds.

43. The method of Claim 40 wherein said ionic characteristic of said plasma further comprises at least one of the group including ion yield, ion energy and average charge state.

44. The method of Claim 40 wherein said first and second laser pulses further comprise two identical pulses split from a laser pulse.

45. The method of Claim 40 wherein said critical density further comprises n, and $n_c = m\omega_p^2/4\pi e^2$ wherein m the electron mass, ω the laser wavelength, and e the electronic charge.

46. A method for vaporizing aggregates in an ablation plume comprising:

a) directing a first laser pulse onto a surface of a target at a first energy fluence sufficient to generate a plasma in the form of said ablation plume;

b) after step a), allowing said plasma to expand to a density approximately equal to a critical density of said plasma; and

c) after step b), directing a second laser pulse onto said plasma at a second energy fluence to vaporize an aggregate in said plasma.